National Aeronautics and
Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

Atmospheric Infrared Sounder

Instrument and Spacecraft Operations Status

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March 30, 2007

Outline

- **AIRS**
  - ***Engineering parameters***
  - ***IR channel frequency shifts over time***
  - ***IR channel health***
  - ***Vis/NIR channel trends***
- **AMSU-A**
- **Aqua spacecraft**
  - ***Anomalies***
  - ***Fuel status***
  - ***Chinese satellite debris***

AIRS—Engineering Parameters

- **The instrument is healthy**
  - ***No worrisome trends in any temperatures, currents, or voltages***
  - ***Occasionally a detector suffers a radiation hit and its noise increases significantly***
    - *More on this later in this presentation*

Cooler Active Drive Levels

- **Cooler A active drive level, after rising steadily early in the mission due to ice buildup, had leveled off**
- **Cooler B active drive level has been very slowly rising since *September* 2005**
  - ***The rate is extremely slow, 0.3% per year, and not a cause for concern***

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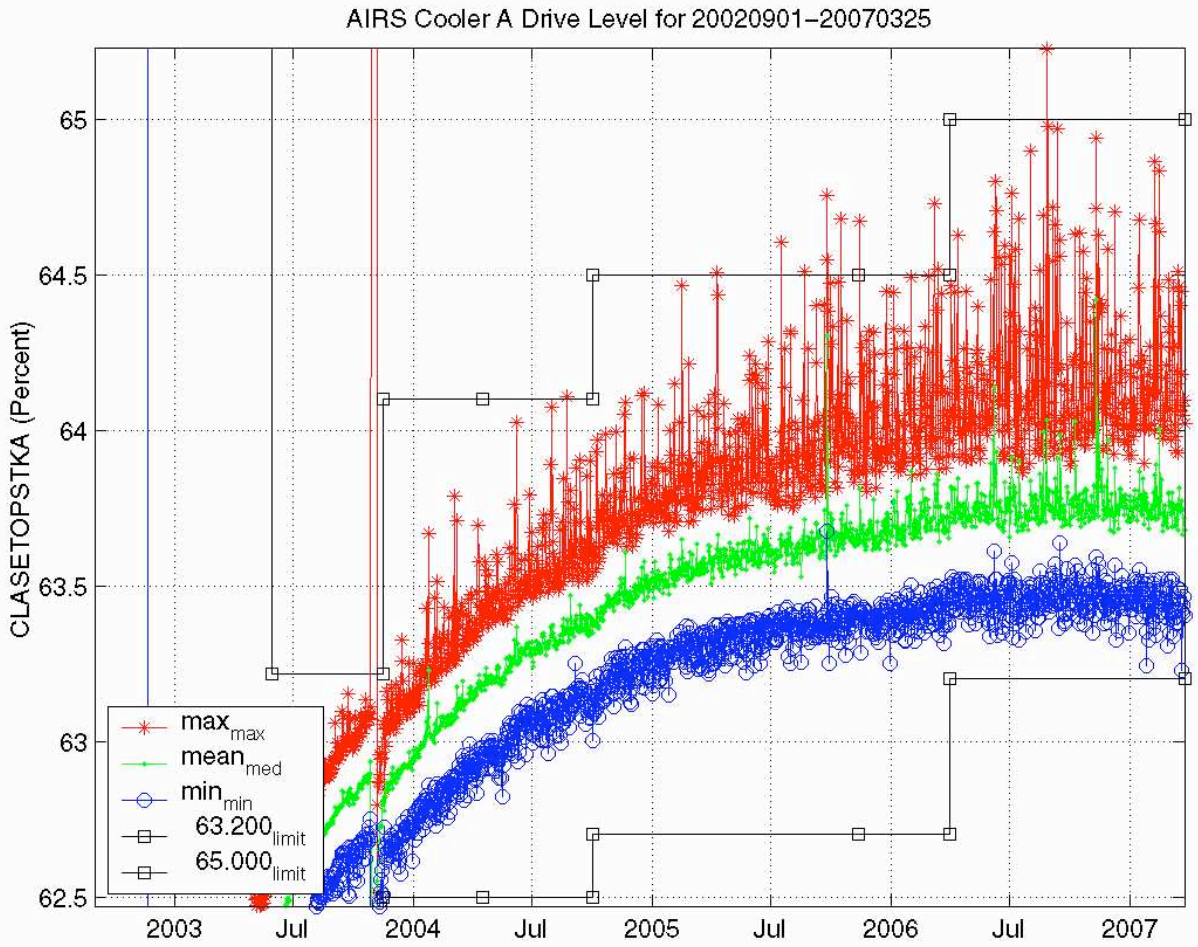
Cooler A Drive Level



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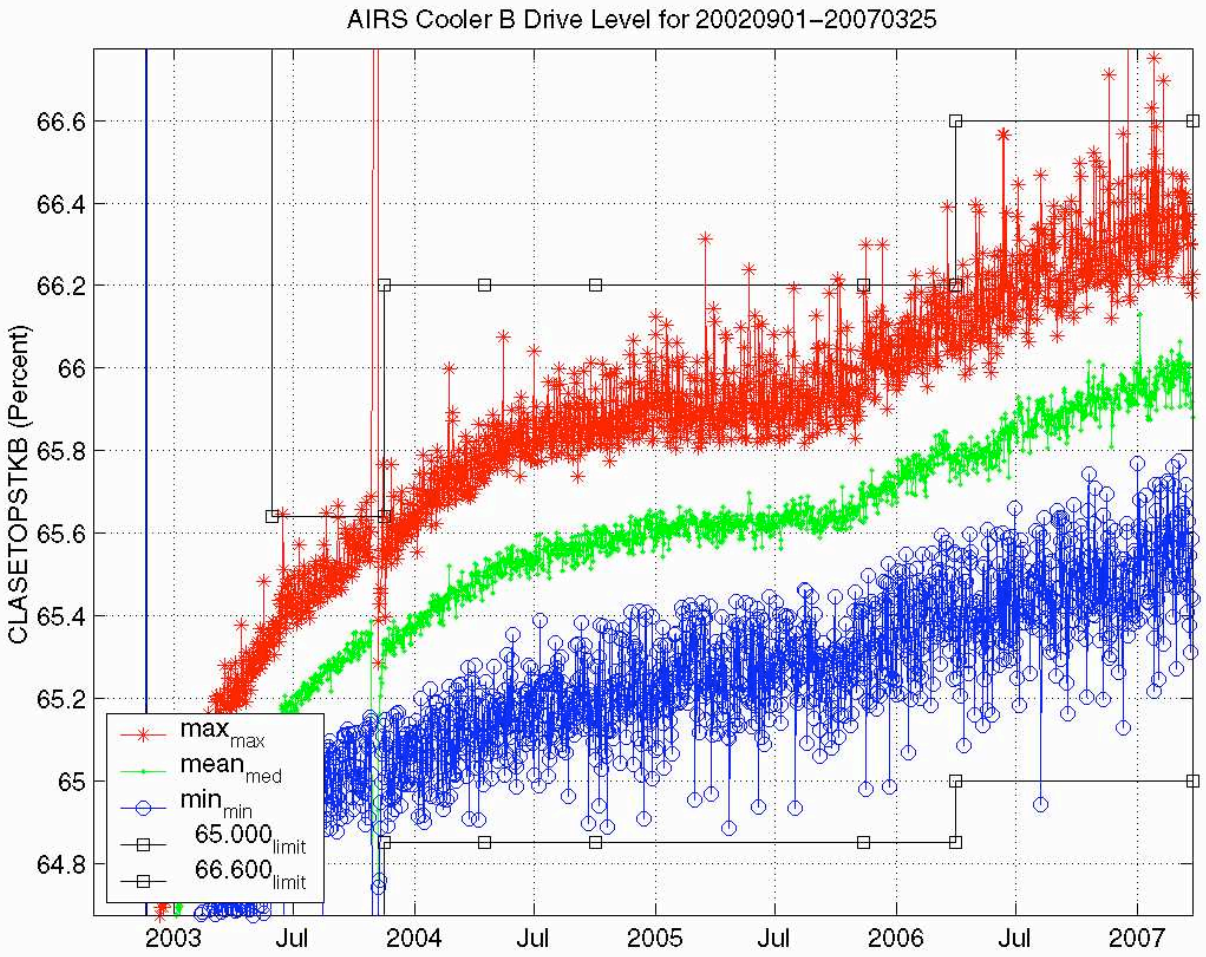
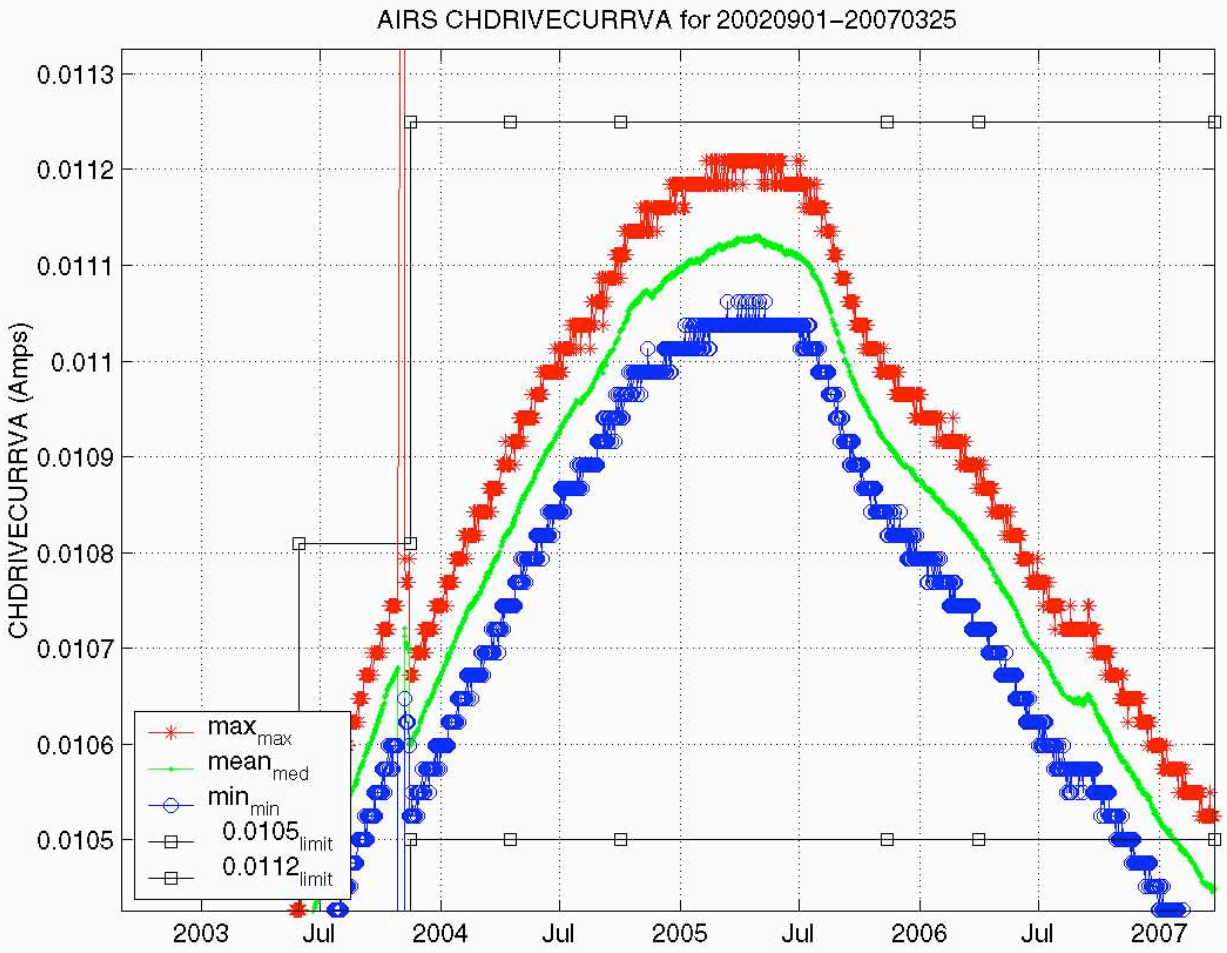
Cooler B Drive Level



Chopper Drive Current

- The daily mean rose steadily early in the mission
- It peaked at 11.13 mA in April, 2005
- Since then, it has been slowly declining, and is now at 10.47 mA, about what it was in July 2003
- Yellow alarm limit is about 18 mA, so we have never been in a danger zone

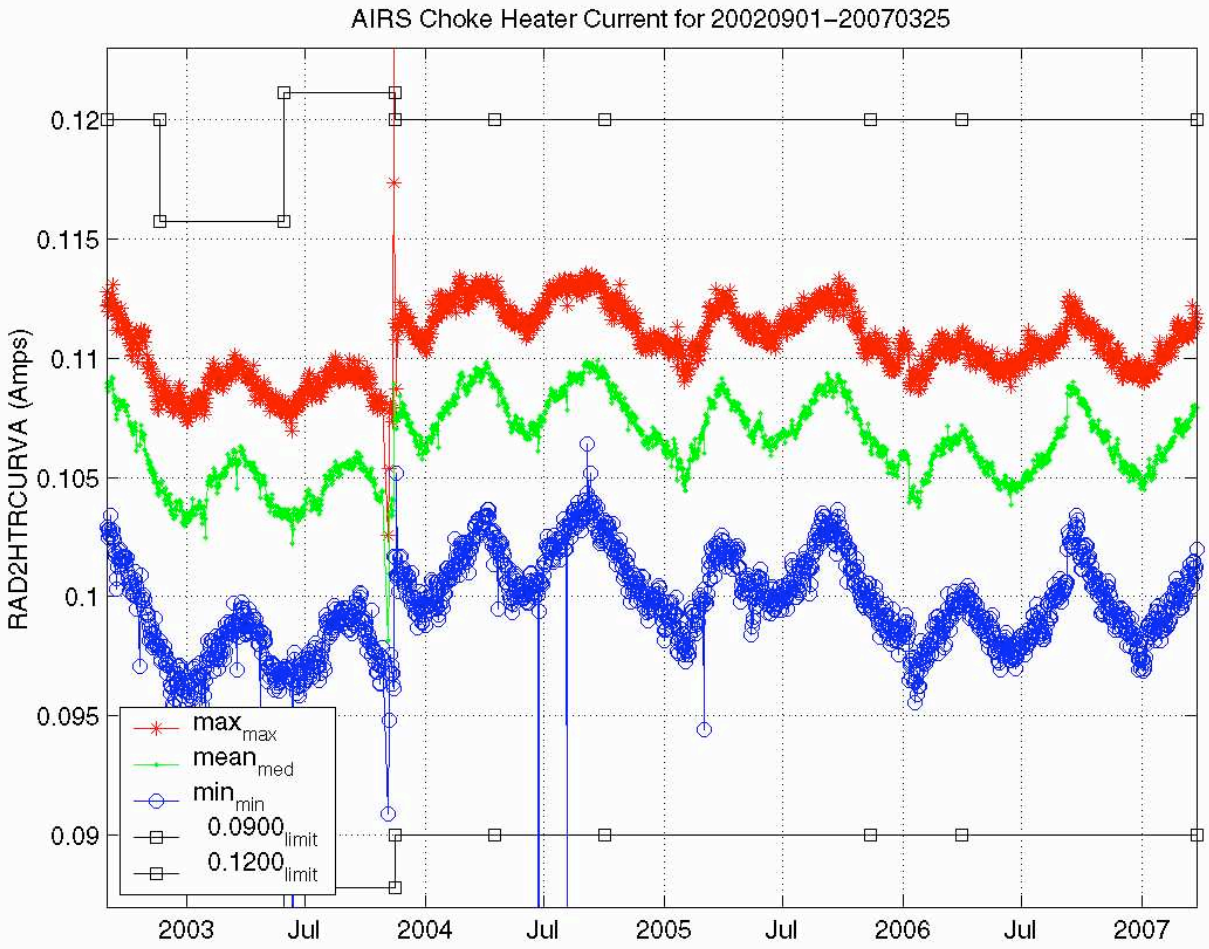
Chopper Drive Current



Choke Point Heater

- Controls the temperature of the second-stage radiator, which is tightly linked thermally to the spectrometer
- Using this heater, we set the temperature of the radiator about six degrees above its natural temperature
- Any tendency for the radiator and spectrometer temperatures to vary on orbital and seasonal time scales is counteracted by this heater
  - *Its current varies under thermostatic control*
- As the radiator ages it is expected to become less efficient, leading to gradually higher spectrometer temperatures in the absence of any temperature control
- As the radiator becomes less efficient, the current in the heater will gradually get smaller to maintain constant spectrometer temperature

Choke Point Heater Current



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Scan Mirror Temperature

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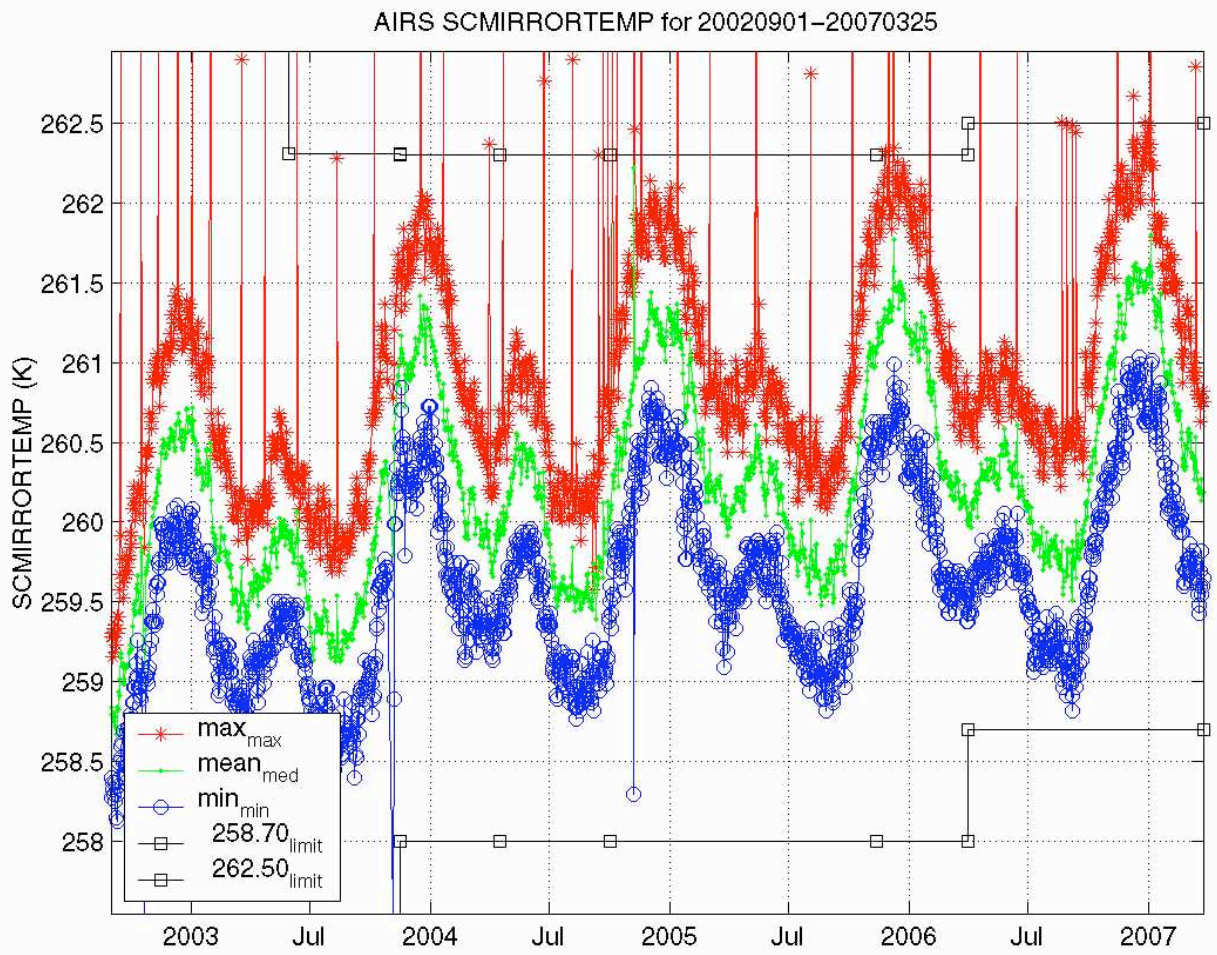
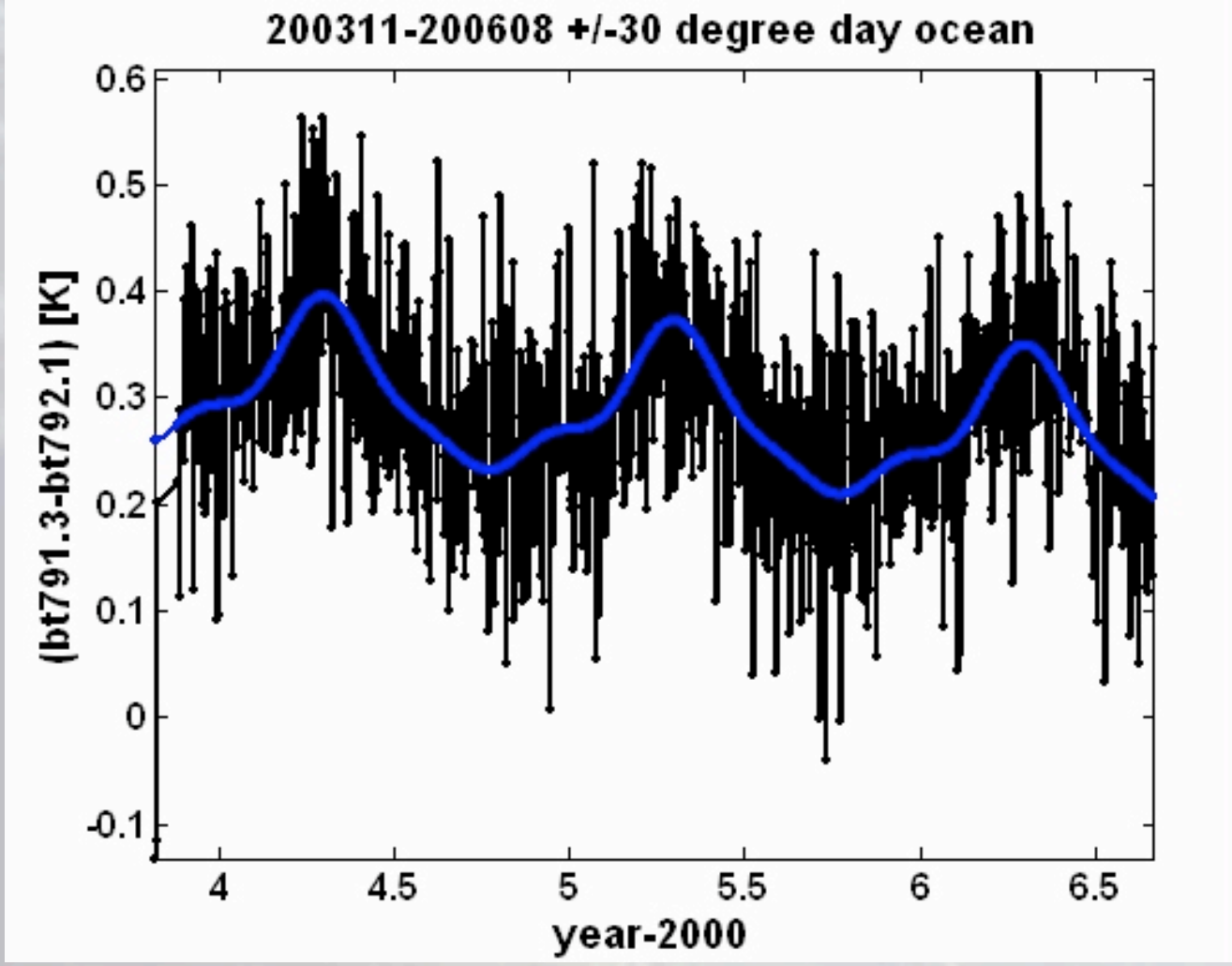


- The scan mirror temperature is rising very slowly
- The trend is about a factor of 10 smaller than the pre-launch prediction

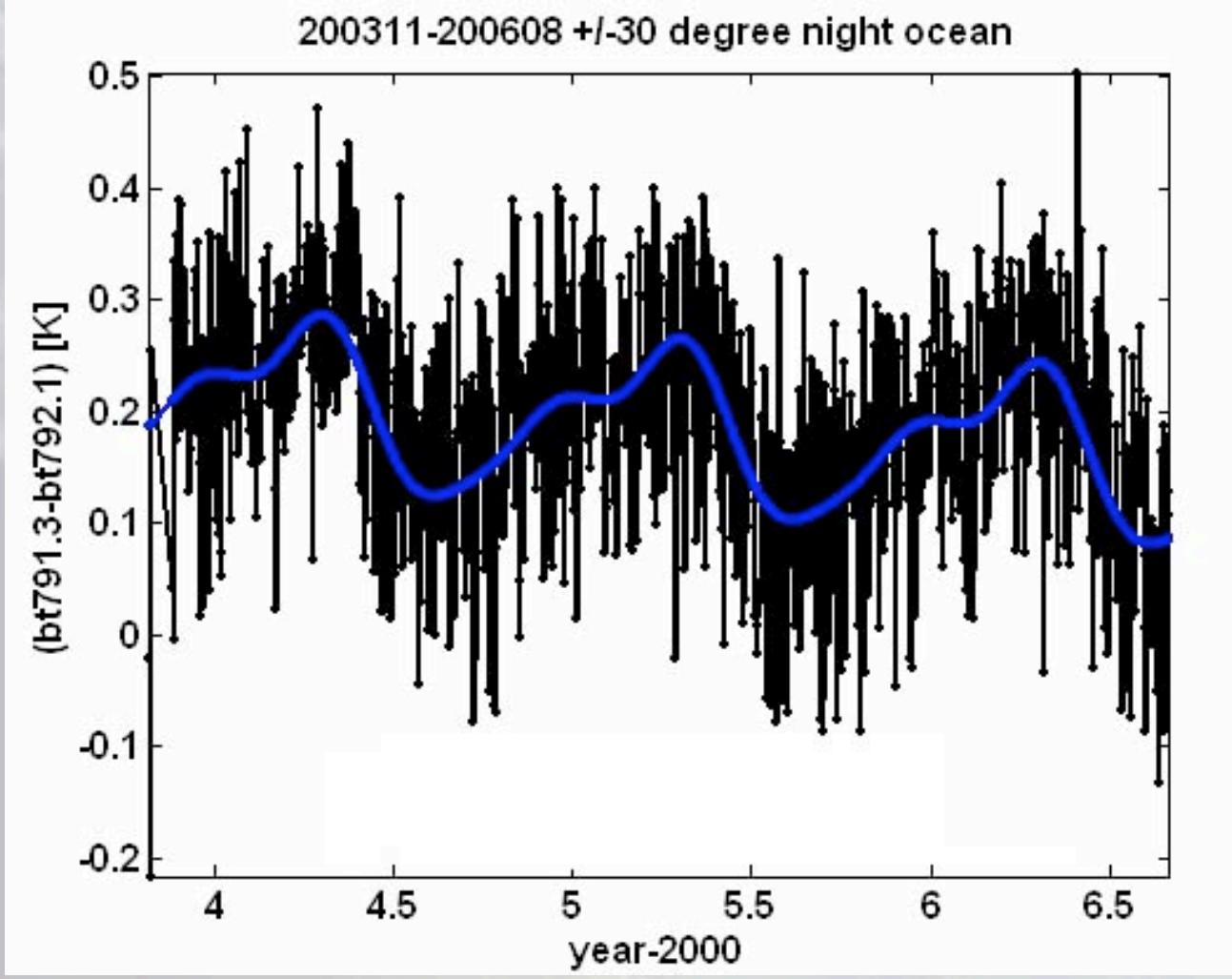
AIRS—Frequency Shifts vs. Time (1 of 2)

- **Three different methods have been used to measure these variations**
  - ***The Level 1B method by Steve Gaiser which uses stable lines in the routinely-observed upwelling radiance***
  - ***Strow's obs-calc analysis for ±30° latitude***
  - ***Aumann's technique which uses two AIRS channels that straddle a CO_2 line***
  - ***The methods generally agree***
  - ***The accompanying figures come from George Aumann***

Daytime Shifts



Nighttime Shifts



AIRS—Frequency Shifts vs. Time (2 of 2)

- **Observed shifts**
  - ***There is a small night/day difference in the channel frequencies of 2.3 ppm***
  - ***There is a seasonal cycle (about 3.6 ppm amplitude)***
  - ***There is also a very small long-term change which may be slowing down—average over the mission so far is 0.54 ppm per year***
- **These shifts are all much less than what was allowed by the AIRS Functional Requirements Document**
- **The observed frequency changes have a negligible effect on the use of AIRS data for weather prediction, but should be properly accounted for in climatological studies**
- **In V5 neither Level 1 nor Level 2 software makes use of any knowledge of dynamic frequency shifting**

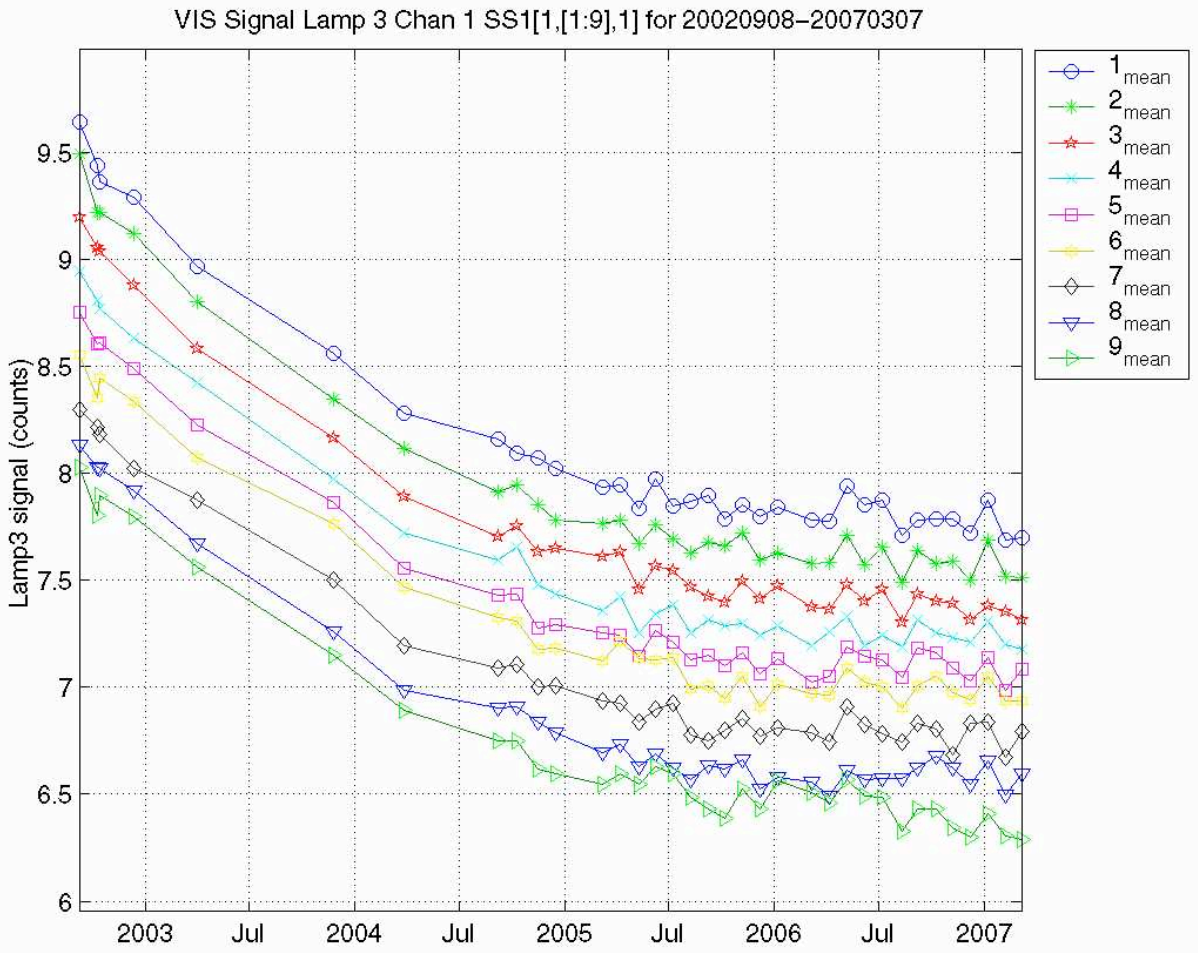
AIRS—IR Channels

- **Every so often a channel's NEΔT increases significantly due to a radiation event (usually in the SAA or the polar horns) or a steady build up of charge**
  - ***Sometimes such channels recover on their own***
  - ***An instrument thermal cycle can cause some detectors to recover while others become noisy***
  - ***These noisy detectors are not dead and not useless—just noisier than spec***
  - ***The criterion to be considered noisy in this sense is "more than 10 granules per day are flagged"***
- **Present status of channels which were in good condition at launch**
  - ***64 detectors are now classified as "noisy"***
  - ***In a few of these cases, only the A side or only the B side is noisy***

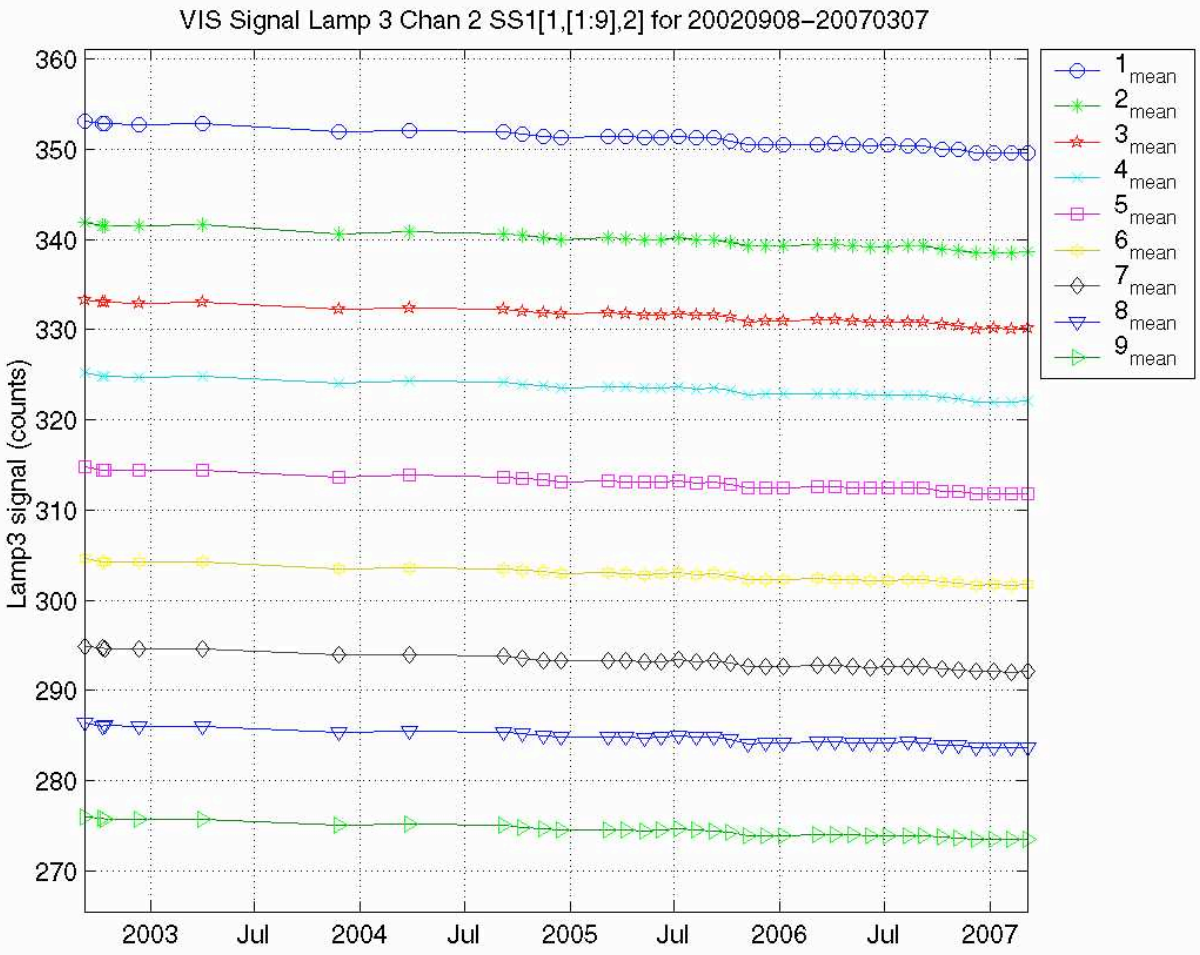
AIRS Vis/NIR Signal

- Since launch, Band 1 has shown a drop of about 18% in signal, as seen during photometric calibrations
- Most of the decrease took place in the first three years
- For the last two years the drop off has been very gradual
- The change is seen regardless of which lamp is used
- Bands 2, 3, and 4 show much smaller effects, so we believe we are seeing degradation or contamination of the scan mirror surface primarily affecting blue light, not a change in the lamps and probably not in the detectors

Band 1 Signal Versus Time



Band 2 Signal Versus Time



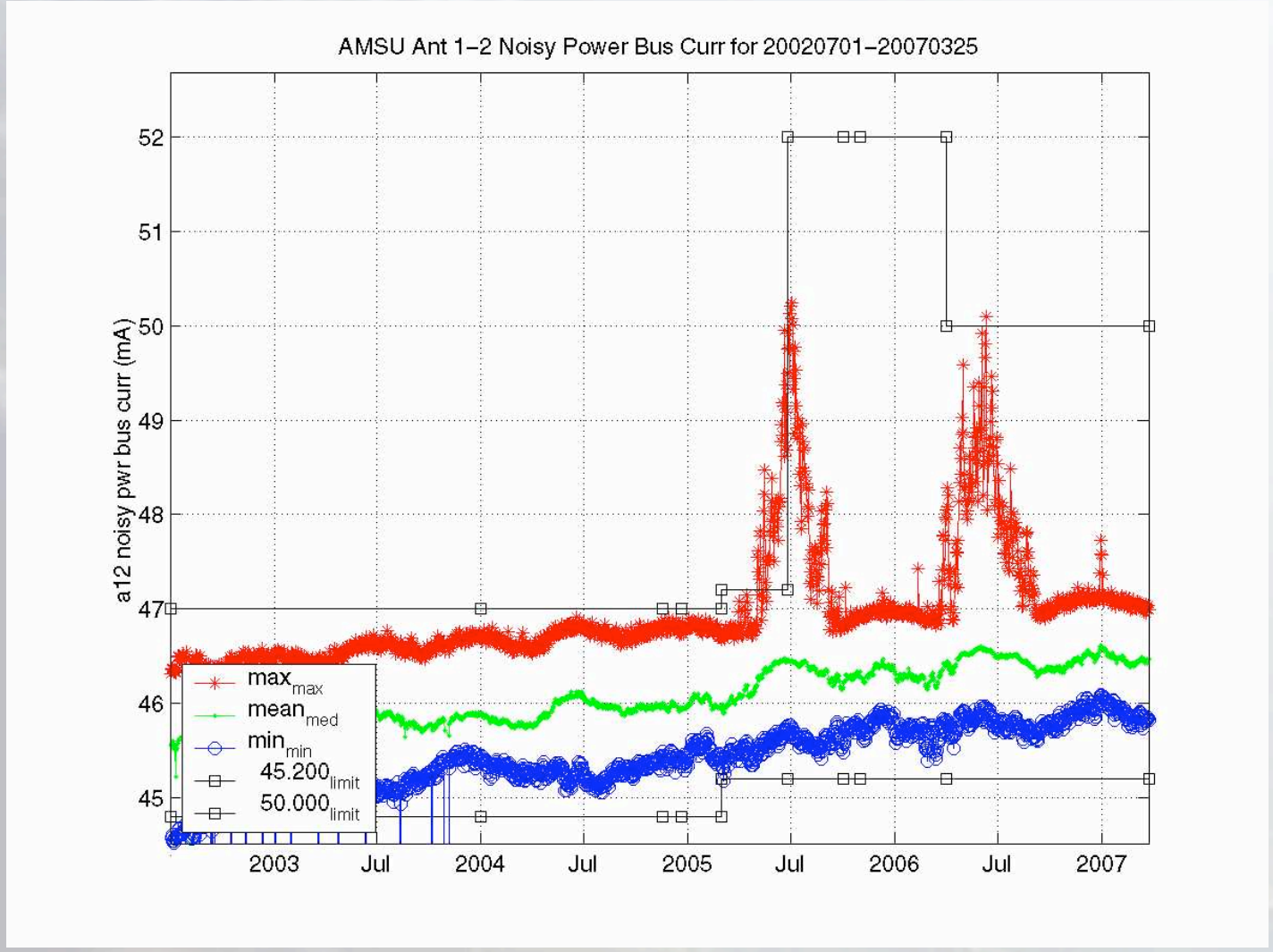
AMSU-A

- **Healthy—all temperatures, voltages, and currents as expected**
- **No significant long-term trends in currents, temperatures, or voltages**

A1-2 Noisy Bus Current "Spiking"

- **For the past two southern winters, current in the A1-2 noisy bus has risen by several mA near the south pole**
  - ***This behavior does <u>not</u> concern the AMSU-A system contractor***
  - ***In late December 2006 we saw for the first time a very small blip near the north pole***

AMSU-A1-2 Noisy Bus Current



RF Shelf Temperature—A Typical Example

- The RF shelf temperature is used here as a typical example
- All AMSU-A temperatures show orbital and seasonal variations of a few degrees
- They also show very slow long-term increases
- The effect of the loss of a capacitor in a temperature measurement circuit on A2 is clearly evident in the following plot

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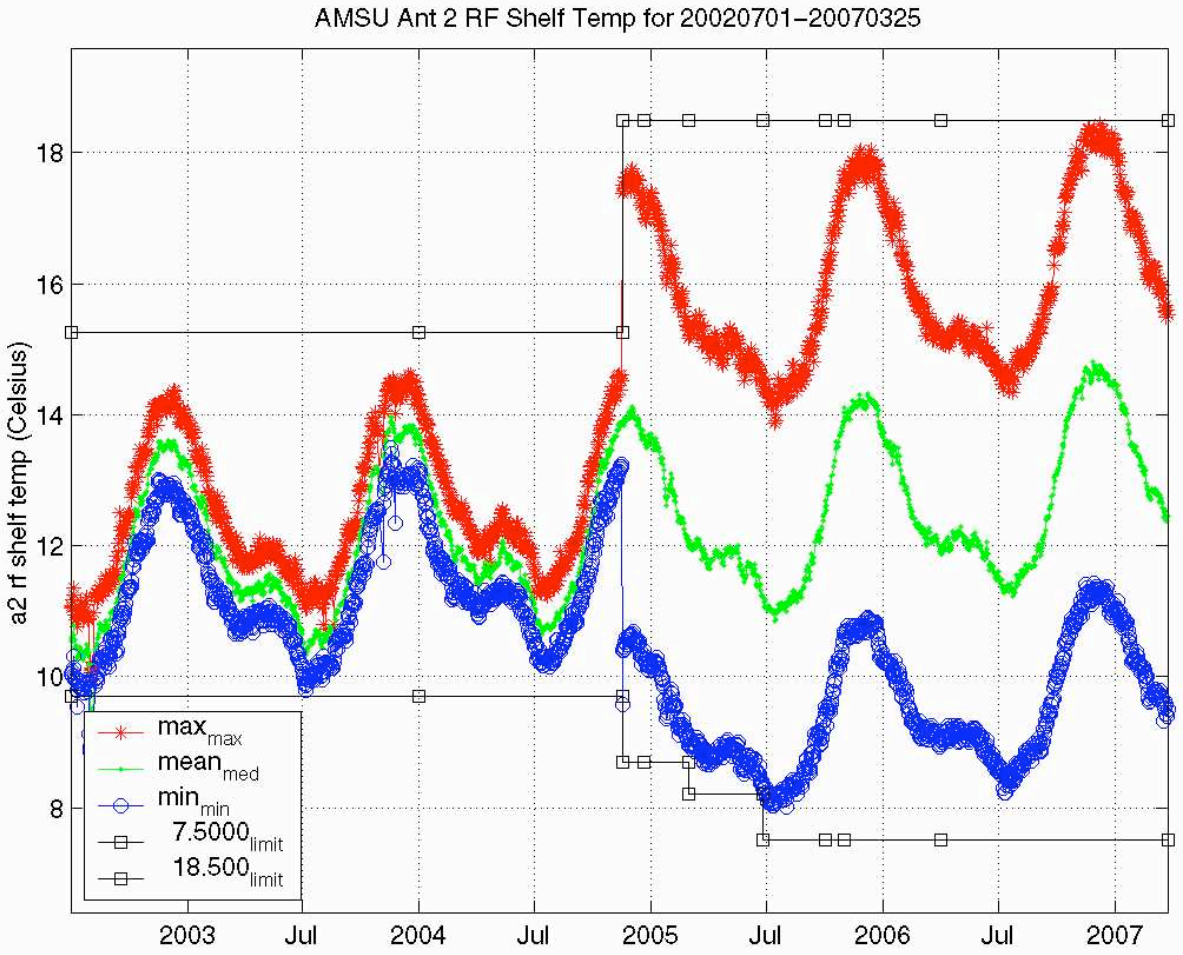
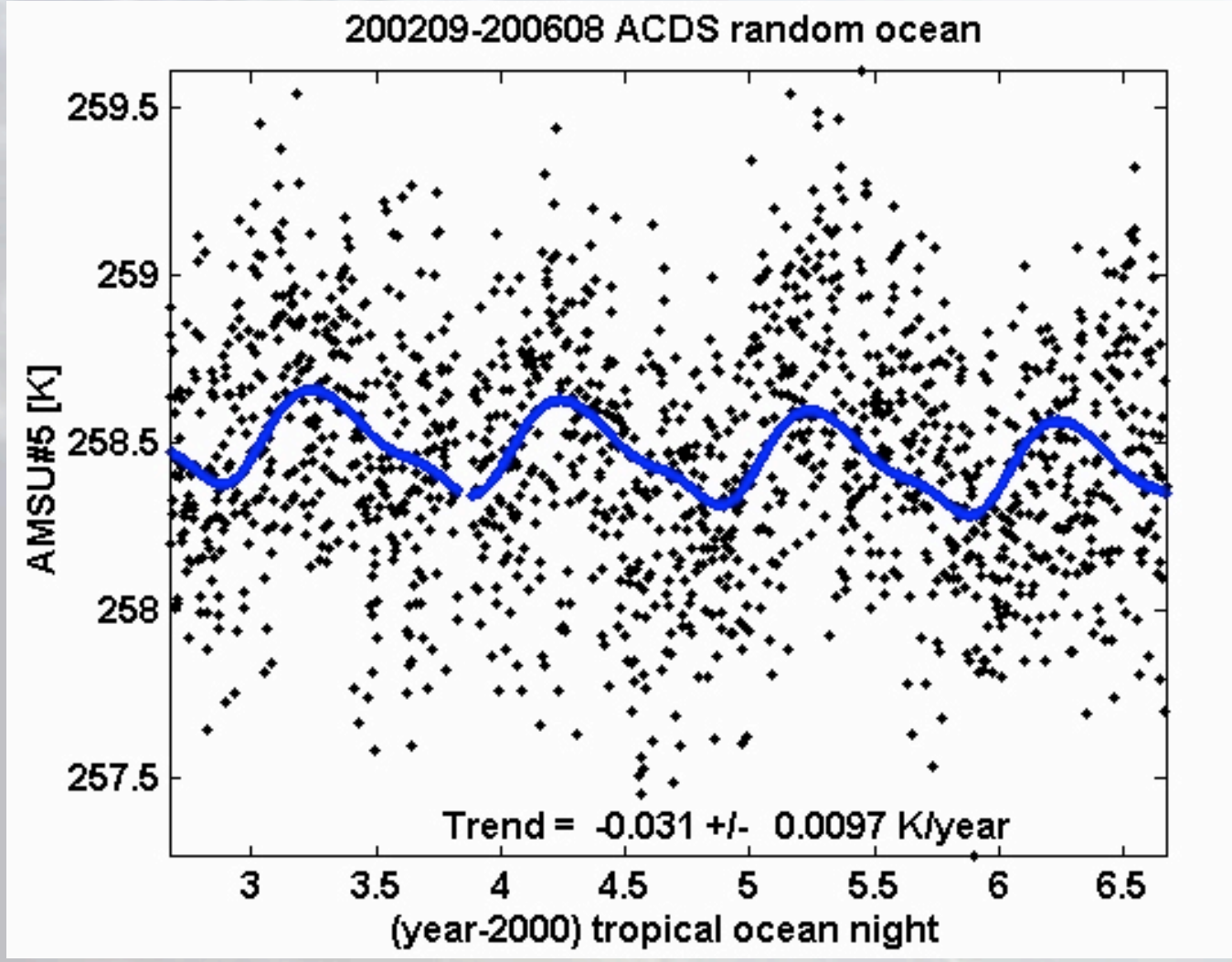
AMSU-A2 RF Shelf Temperature



AMSU-A Ch 5 4-year Trend



Aqua Spacecraft Status (1 of 2)

Atmospheric Infrared Sounder

- **Aqua spacecraft is generally healthy**
- **Five anomalies have occurred, but there has been no permanent impact on operations**
- **Three were related to the power generation system and/or batteries**
  - ***Solar array drive assembly potentiometer has occasional anomalies—most recently on February 21 2007***
  - ***ARE 4A power drop on September 9 2004 (recovered October 8 2004)***
  - ***Battery Module Assembly #2 Cell #4 overheated on 9/2/2005—there have been occasional anomalies in the same cell since***
    - Final closeout report issued in March 2006—root cause unknown
    - A new charging profile is being developed in an effort to prevent further problems

Aqua Spacecraft Status (2 of 2)

- **One anomaly involved the solid state recorder**
  - ***On December 22, 2006, during a routine playback, the playback halted unexpectedly***
    - This incident is still under investigation
    - It has not been repeated
- **One is actually a class of anomalies**
  - ***Commands in the daily spacecraft command load have occasionally been dropped and did not make it to the spacecraft***
    - Neither AIRS nor AMSU-A were ever affected
    - The problem appears to reside at one particular ground station in Alaska
    - Still under investigation
    - The suspect ground station is not being used, pending resolution of the anomaly

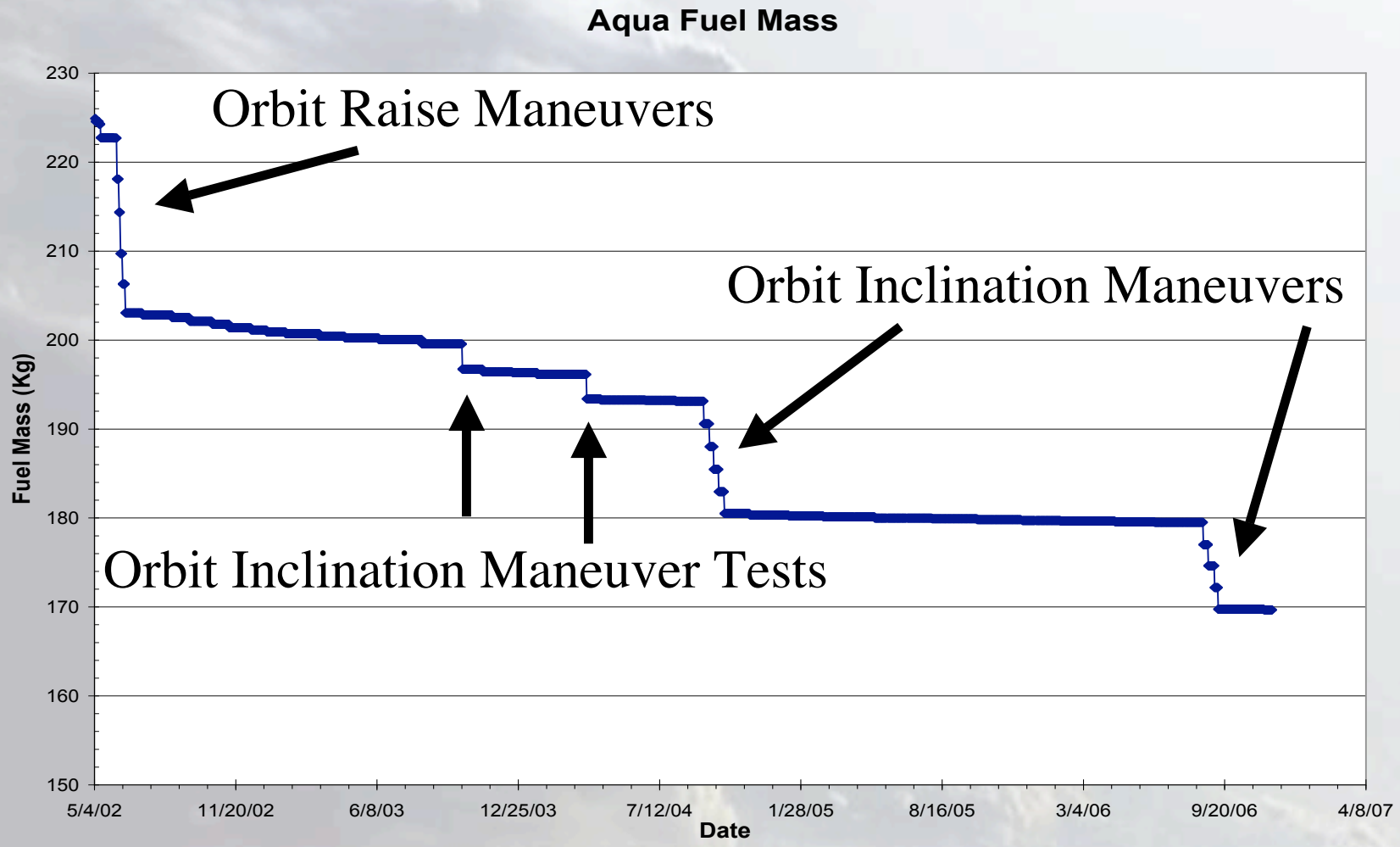
Aqua Spacecraft Fuel Consumption (1 of 3)

- **Given current trends, the primary life-limiting resource is fuel for maneuvers**
  - ***225 kg fuel on board at launch***
  - ***The required re-entry reserve is unclear, but a worst case amount of 125 kg is now being carried***
  - ***Thus, 100 kg were available at start of mission, with much more available if the re-entry reserve requirement can be relaxed***
  - ***A series of four IAM's is now in progress. Before it started we had 170 kg left on board***
    - About 20 kg were used in post-launch orbit adjustments
    - About 15 kg were used in a series of inclination adjustments in fall 2004
    - About 8 kg were used in two IAM's in September 2006

Aqua Spacecraft Fuel Consumption (2 of 3)

- The 12 kg not accounted for in the above list was mostly used in tests of the IAM's prior to the first series in 2004
- Drag make up maneuvers use an almost negligible amount of fuel
- The Earth Science Mission Operations Flight Dynamics unit at GSFC estimates that, given current usage patterns and plans, Aqua has enough fuel to last at least through 2015
  - *That estimate assumes a re-entry reserve of 125 kg, which may be higher than will actually be required*

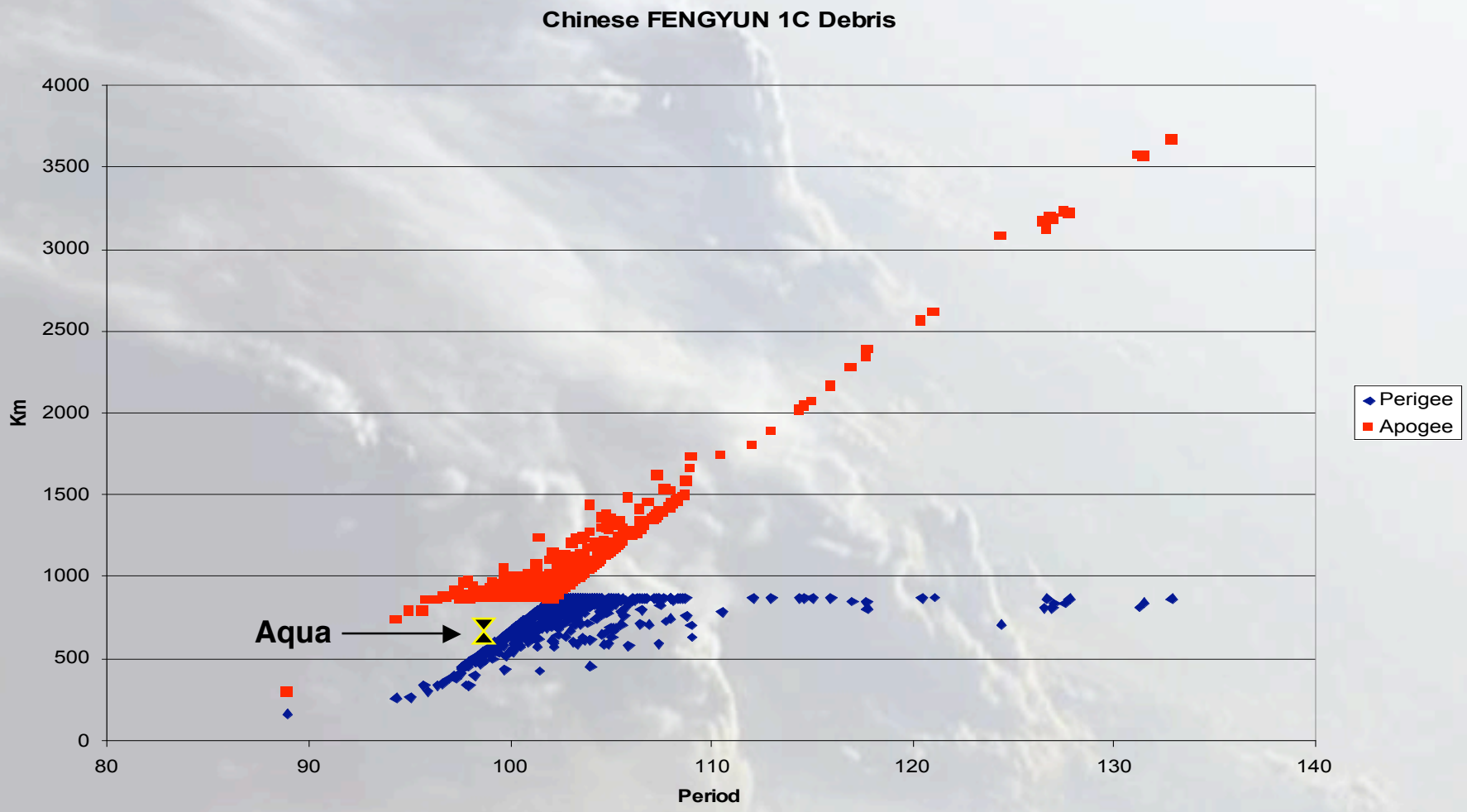
Aqua Spacecraft Fuel Consumption (3 of 3)



Fengyun 1C Debris

- On January 11th, 2007 China performed a successful test of an anti-satellite (ASAT) weapon
- The ASAT test consisted of a medium-range ballistic missile destroying a Chinese weather satellite
- Event occurred at an altitude of ~535 miles (861 km)
  - *Several hundred pieces were generated*
- As of February 15th, over 750 pieces of debris had been cataloged
- The debris population has a range of mean equatorial heights from 400 to 2100 km
  - *Most of the debris is in the 600 – 1000 km range*
  - *75% lies below 931 km*
- Debris inclination range is 96 – 102 degrees
  - *93% lies between 98 and 101 degrees*

Apogee & Perigee vs Period (Gabbard Diagram)



BACKUP

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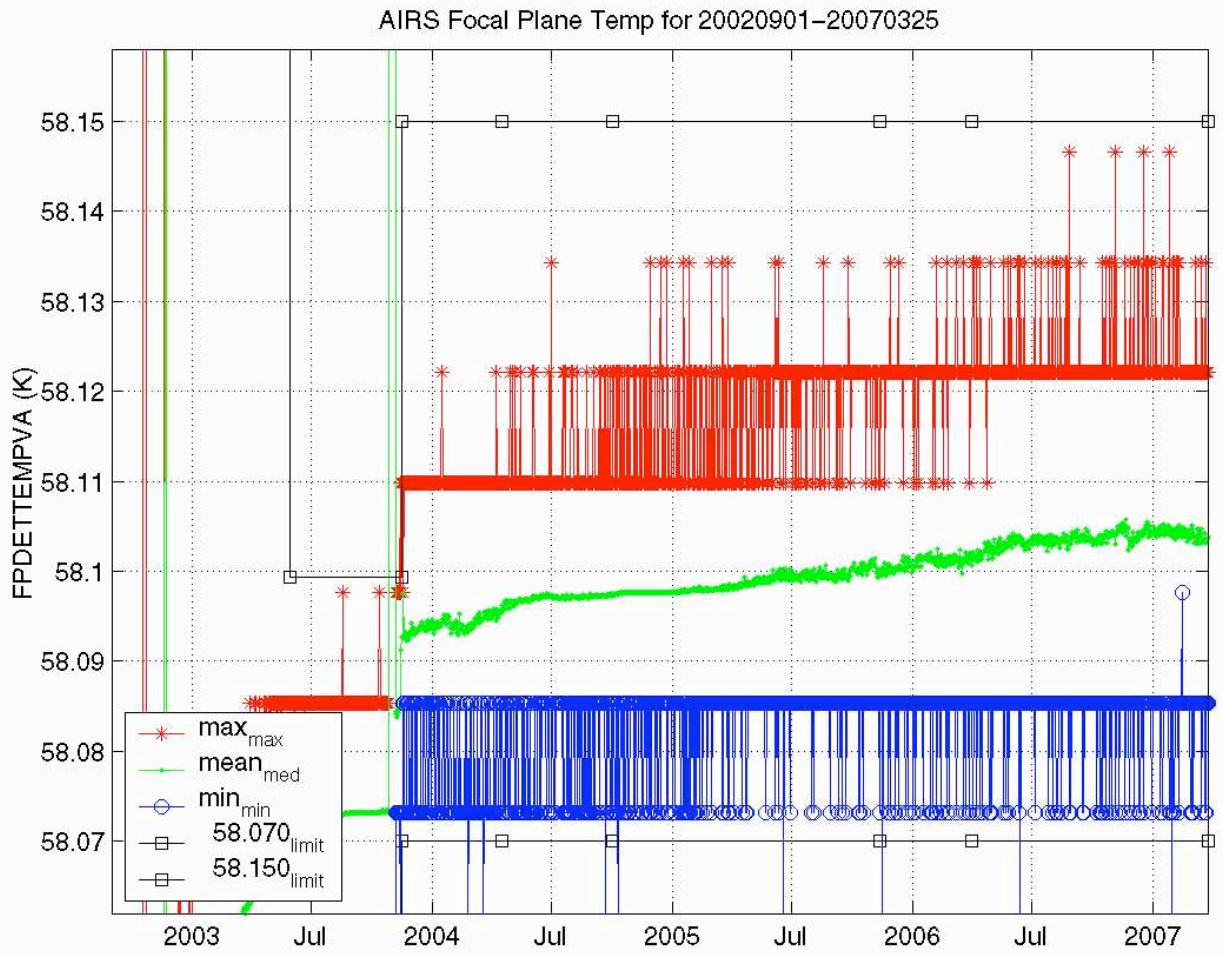
Focal Plane Temperature



Band 3 Signal Versus Time